Determining CoTE for Concrete

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INTRODUCTION

Early-age distress, primarily shallow spalling, in continuously reinforced concrete pavements (CRCP) in Texas has been a problem for several decades. This type of distress comprises almost 50% of the distresses observed in CRCP. Over the past 20 years, repairs of these early-age shallow spalls have cost TxDOT nearly $500 million in the Houston District alone. Through years of research, the majority of these early-age distresses have been linked to use the of coarse aggregates with high coefficient of thermal expansion (CoTE). In early 2000's, several Districts began requiring concrete for CRCP to have CoTE values of 6.0 µ-strain/°F or less. This resulted in the elimination of virtually all the early-age spalling.

Figure 1: Typical Shallow Spalling in CRCP

As TxDOT began requiring CoTE testing for concrete pavements, questions arose as to the correct way to determine the CoTE value of concrete. In the early 2000's, TxDOT's Materials and Pavements Concrete Laboratory began measuring CoTE of concrete by continuously measuring the movement of the concrete as the temperature changes. The CoTE value is then determined by calculating the slope of the data.

Over the past 13 months, due to inconsistencies in the CoTE data, several modifications were made to the test equipment and calibration procedures that have greatly improved the overall process.

TEST SETUP AND RESULTS

The original test setup used a typical LVDT to collect the displacement data, but due to the configuration of the frame and water bath, this left the majority of the LVDT housing out of the water bath which seemed to have an effect on the CoTE value of the sample.
The sample height also resulted in variations in the CoTE value of the same sample. These issues seem to be corrected by switching to a temperature compensating DVRT device.
The correction factor for each frame and DVRT setup is established by testing a ceramic cylinder having essentially a 0 µ-strain/°F CoTE value. Any movement recorded is due to the movement of the test frame.

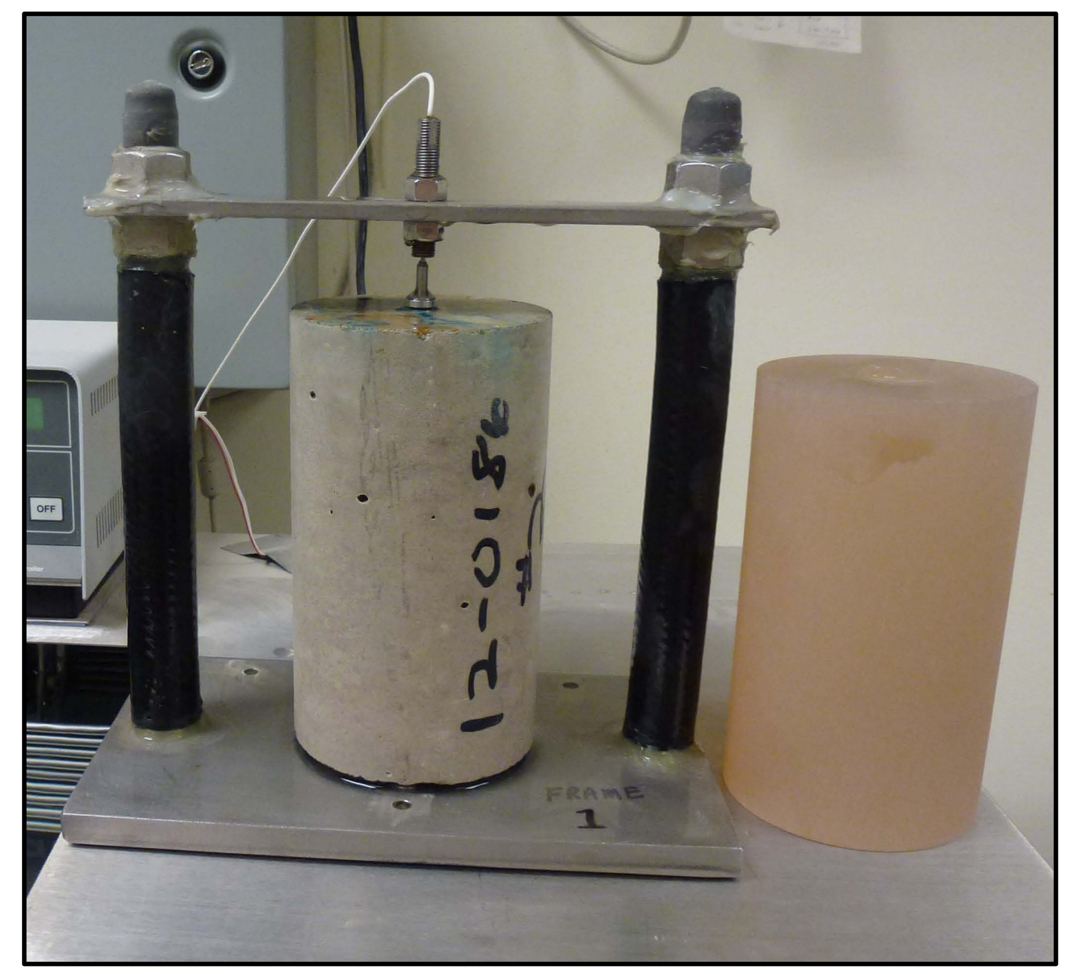


Figure 2: CoTE Test Frame with Sample and Ceramic Cylinder

Figure 3 shows the raw data collected during testing. The concrete sample is cycled three times between 10°C and 50°C. At the end each end point, the temperature is held constant for 30 minutes. The displacement of the sample is continuously measured for each cycle. Data from cycle 2 and cycle 3 are used to calculate CoTE value.

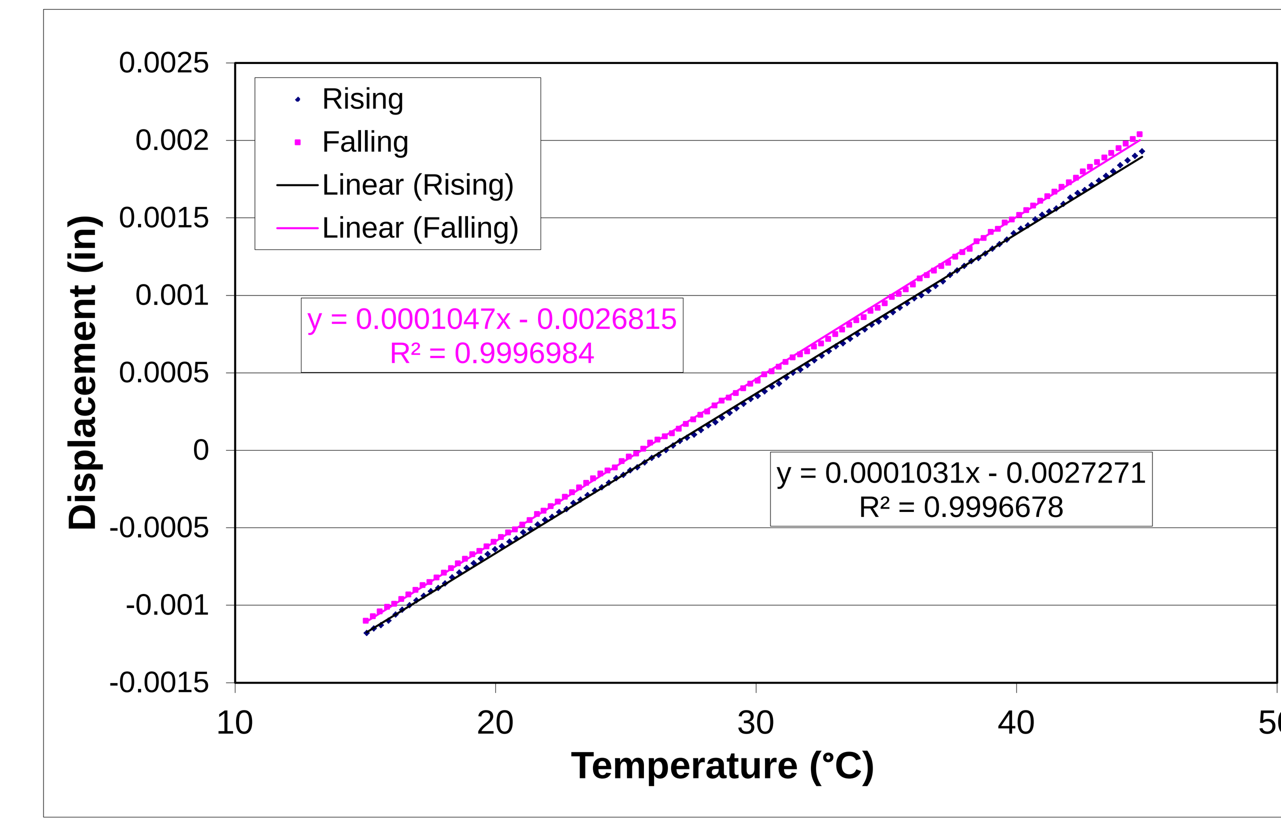


Figure 3: Typical Raw CoTE Test Data

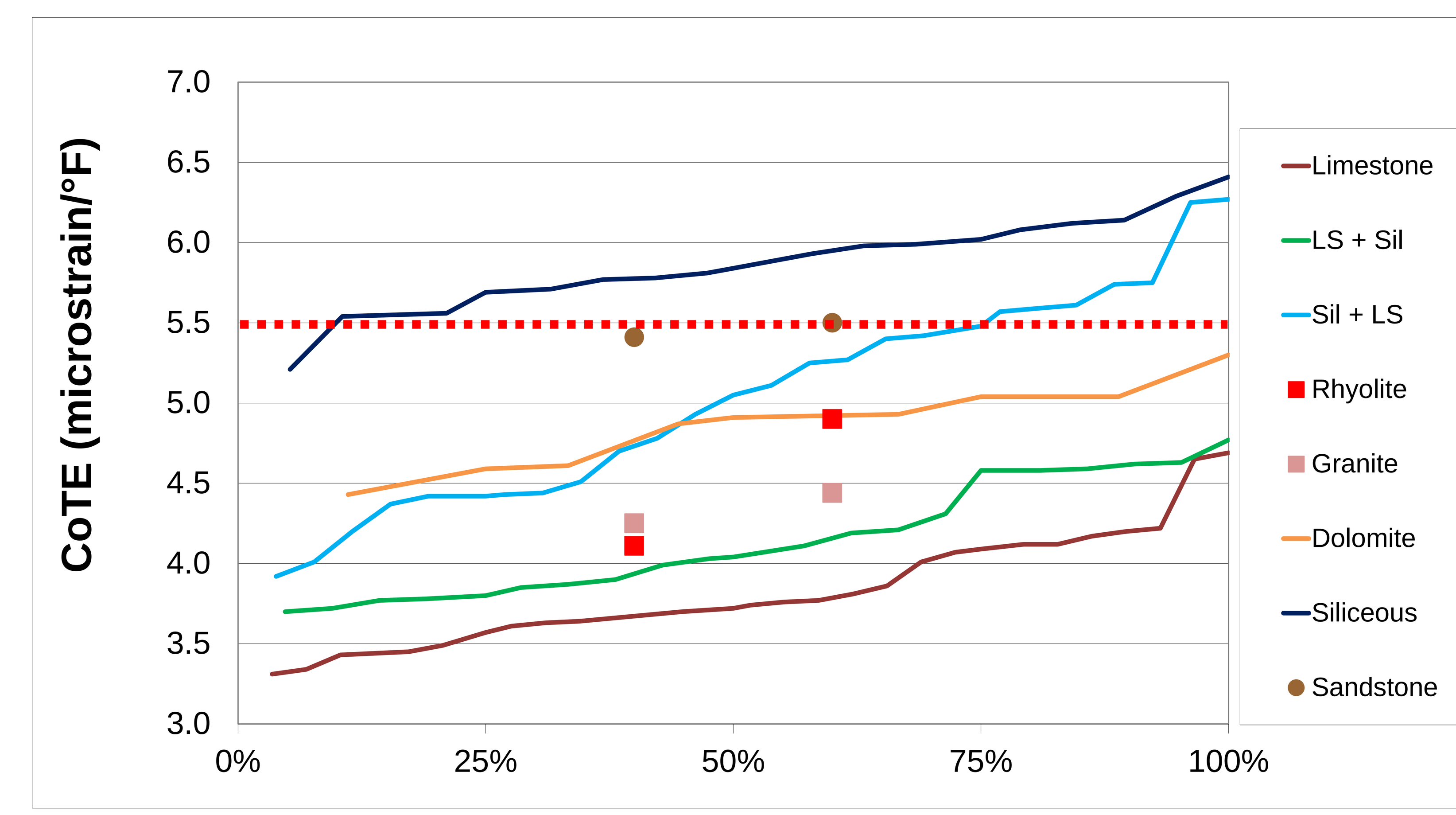
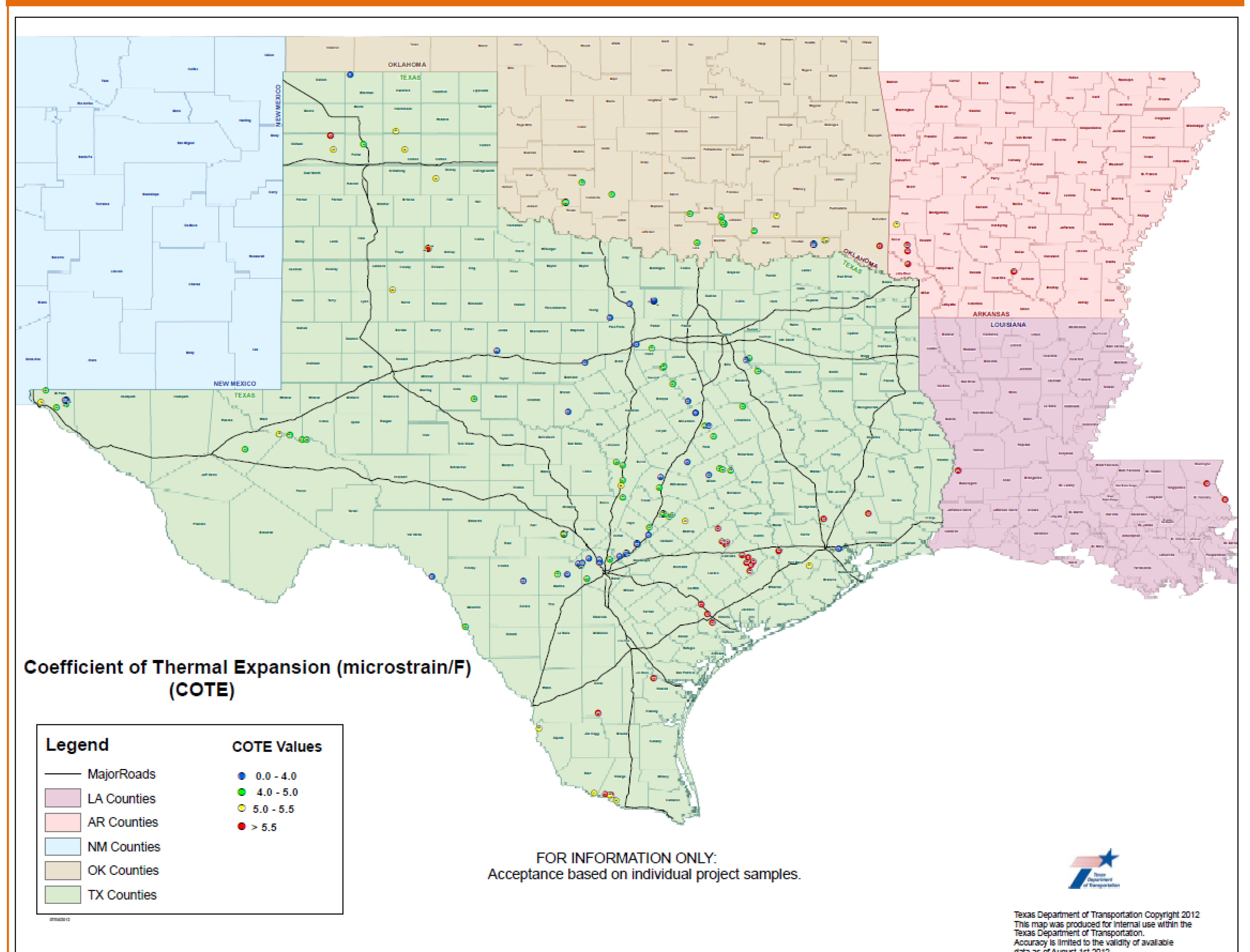


Figure 4: Frequency Distribution of CoTE Data by Aggregate Type

Figure 4 shows the frequency distribution of the all the CoTE values for different aggregate material types. The red line at 5.5 µ-strain/°F is the proposed maximum specification limit for concrete pavement.

CoTE VALUES FOR COARSE AGGREGATES USED IN TEXAS



CONCLUSION

The early-age spalling in CRCP in Texas has been a costly issue for a number of years, and with reduced funding, TxDOT can not afford to continue to construct CRCP's that will experience this type of distress. TxDOT has determined that the CoTE of the concrete has a significant impact on the short and long-term performance of CRCP, and has drastically improved the ability of accurately determining the CoTE of concrete. The proposed maximum specification limit of 5.5 µ-strain/°F will restrict the use of coarse aggregates that have caused early-age distress in the past, which in turn will extend the service life of newly constructed concrete pavements. As the map to the left shows, Texas still has large number of coarse aggregates available, that when used in concrete pavements will meet this new CoTE specification.